

**QUARTERLY PROGRESS REPORT**

**DRD 875MA-003**

**October 2004 – December 2004**

**Marshall Space Flight Center  
Safety and Mission Assurance Mission Services Contract  
NAS8-00179**

**Approved:**

**Original signed by:**

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## **1.0 INTRODUCTION**

Hernandez Engineering, Inc. (HEI) successfully performed all required activities and tasks, as described in this report, in fulfillment of their Safety and Mission Assurance (S&MA) Mission Services Contract (NAS8-00179) with NASA's Marshall Space Flight Center (MSFC). This report covers a three-month period of the contract's first quarter of the fourth option year: October 2004 through December 2004.

## **2.0 GENERAL MANAGEMENT**

### **2.1 Data Requirements**


The first quarter of the fourth option year of the S&MA Mission Services contract was successfully completed on January 2, 2005. All Data Requirements (DR) Documents were submitted on or ahead of schedule throughout the quarter. They included DRD 875CD-001 On-Site Employee Location Listing; DRD 875MA-002 Financial Management Reports; DRD 875MA-003 Progress Reports (Monthly/Quarterly); DRD 875MA-006 Operations Plan, Problem Assessment Center (PAC); DRD 875MA-007 Quarterly Open Problems List; DRD 875MA-008 Monthly Newly Opened/Closed Problem Summary; DRD 875SA-002 Mishap and Safety Statistics Reports; and Quarterly Safety Performance Evaluation.

### **2.2 Personnel Status**

(b)(4)

## **3.0 BUSINESS MANAGEMENT**

We have experienced no financial or business management problems during this period. We attribute this to close attention to details, effective use of established controls designed to efficiently respond to program changes---both anticipated and unexpected---and the continuing support of our corporate financial group's dedicated efforts at controlling overhead expenses.

The contract continues to have a total cost under-run at the end of this period---see the December 2004 Monthly Financial Report, DRD 875MA-002, for specifics. Attachment 2, Man-Hours Expended, of this report contains a description, by major task, of the total man-hours expended this period. 

(b)(4)

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## **4.0 PERFORMANCE OF WORK AND USE OF FACILITIES AND EQUIPMENT**

### **4.1 Safety**

#### **4.1.1 Industrial Safety (IS)**

The Industrial Safety (IS) group performed 13 OSHA compliance annual facilities inspections and provided all required reports in a timely manner, this completing the annual inspections for CY04. Also, IS prepared and submitted, for Industrial Safety Department (ISD) approval, the draft schedule of annual facilities inspections for CY05, and performed 354 construction site compliance inspections to monitor adherence to OSHA and MSFC safety standards. All facility safety violations were documented in the SHEtrak database in order to assure MSFC's compliance with OSHA, NASA, and other consensus code requirements.

Among other activities, IS: (1) participated in three final safety inspections of facilities under renovation or construction; (2) in 83 facilities, performed on-site verification checks of findings reported closed by responsible organizations, this completing the verification checks for CY04; (3) reviewed 60 sets of facility design drawings for compliance with OSHA and consensus codes; (4) assisted the ISD in the development for web page posting, five Safety Bulletins and three Shop Talk safety information topics; (5) taught three training sessions to supervisors on how to perform monthly workplace safety visit inspections; (6) as part of one class for building managers and their assistants, taught identification of hazards in the workplace, (7) performed 43 annual fire drills; and, (8) participated in two preconstruction conferences of facilities being modified or upgraded.

Although not a designated contract year Area of Emphasis (AOE), IS agreed to continue the emphasis to increase awareness of identifying Unsafe Acts in the workforce. IS identified Unsafe Acts with emphasis of on-the-spot corrections and prepared numerous general safety awareness communication messages for ISD to distribute to Center employees. To assist in this effort HEI continued to provide an experienced senior Industrial Safety engineer to assist in identifying Unsafe Acts. In addition, this same part-time employee surveyed 301 locations to assure adherence to Lockout/Tagout requirements when working on energized systems and monitored construction and maintenance activities, which included spot checks after normal work hours and weekends.

IS continued to provide: (b) (4) to assist the SHE Communications and Training Teams and general communication of safety awareness to all MSFC employees. Assistance included: (1) prepared and processed, for web page posting, the weekly SHE highlights and monthly SSWP safety required and optional focus topics; (2) prepared monthly SHE communications plans; and, (3) developed multiple innovative safety awareness communications materials including safety announcements on MSFC TV.

In support of a recent S&MA Technical Directive, IS: (1) continued to provide additional administrative and technical support to the SHE Committee to assist with preparation of annual SHE Program progress reports for CY 2003 and CY 2004, preparation of the CY 2005 SHE Program Annual Plan, and tracking of SHE actions; (2) continued to assist the SHE Committee Chairperson and ISD support bi-monthly SHE Committee meetings, including collection and organization of pre-meeting briefing charts, serving as recorder, and preparing draft meeting minutes; (3) assisted ISD and the SHE Committee with the 10/04 Third Party Assessment of the MSFC SHE Program by STAR Consultants, Inc.; and, (4) to assist in documenting and tracking SHE Committee and external SHE Program evaluation action items, IS continued to coordinate with the HEI IM Group, ISD and the SHE Planning Team to initiate development of a new S&MA database, which is named SHE Committee Action Item Tracking System (SHECAITS). As an update to last quarter's report which stated that HEI self-initiated hiring an additional employee for the IS team to assist with these additional requirements, this employee was enthusiastically appreciated by the SHE Committee and ISD key personnel.

IS initiated, completed or followed-up on more than ten hazard analyses. Examples include: (1) the RTF Heaters and Control System testing; (2) the SRTM-ICXL Motor test; (3) the Metal Combustion test in the PRL; and, (4) the Micrometeoroid/Space Debris Impact Facility Light Gas Gun.

IS continued to support the implementation of the NASA lifting standard, NASA-STD-8719.9 by providing day-to-day advice and assistance to S&MA customers. IS advised civil service and contractor managers, supervisors and employees on requirements for lifting equipment usage in support of the MSFC SHE Program. IS served as the on-site safety move monitor for the lifting and handling operations associated with the ECLSS OGS#3 delivery at building 4570 and for the T-Rex fossil in building 4707. Also, IS continued to be an active participant in the Lifting Device Equipment (LDE) SHE subcommittee.

In support of the task to administer proficiency exams to civil service and contractor operators of overhead cranes, fork lifts, small truck mounted hoists, and aerial lifts, IS administered hands-on proficiency examinations to eight overhead crane and 12 forklift operators in support of the MSFC Personnel Certification Program. With these exams, IS performed 155 proficiency exams for CY04.

IS continued to provide dedicated, (b) (4) to the MSFC Test areas. Examples of support included: 1) reviewed and approved multiple operating and test procedures for hazardous operations; 2) reviewed the Quantity-Distance (QD) requirements for the potential propellant storage facilities in the test areas; 3) reviewed the RTF TPS Verification Wide Panel Testing test plan in Building in 4619; 4) actively participated in daily and weekly safety meetings/safety stand downs of Test and Evaluation Department, Space Transportation Directorate; 5) as an additional duty, served as the alternate safety representative for test area facilities; and, 6) provided daily support to test engineers and S&MA personnel on technical issues to include performing numerous test procedure reviews.

#### 4.1.2 System Safety Engineering

System Safety Engineering (SSE) served as the MSFC S&MA representative on the Space Shuttle System Safety Review Panel (SSRP) in multiple TIMs. The topics addressed included ET Thermal Protection System (TPS) risk documentation, ET Hazard Report (HR) T.02 (Loss of TPS) and related CIL items, the Enhanced Caution & Warning System for the Extravehicular Mobility Unit, two discussions with the SRB project resulting in a new HR to address SRB Primary Structure, seven (7) HRs (ORBI 036, ORBI 240, ORBI 021, ORBI 279, ORBI 339, ORBI 040, and ORBI 81) presented by the Orbiter project, and a presentation by Shuttle Integration describing the Integrated Hazard analysis strategy and related preliminary fault for debris.

SSE presented a series of reports to the S&MA Director on the status of the MSFC Elements RTF activities with the SSRP. The presentations addressed ET Hazard Reports, the history of the SSRP RTF reviews for SRB and RSRM Hazard Reports and Critical Items Lists (CILs), and finally focused on the current status of all four of the MSFC Space Shuttle Program (SSP) Element projects and the very active schedule required to complete the SSRP RTF activities. SSE will continue these presentations until the return-to-flight effort is completed, to assure management awareness of project status and the issues and concerns arising from SSRP activities.

SSE supported the daily meetings of the RCC (Reinforced Carbon-Carbon) On-Orbit Crack Repair (ROCR) team, which included reviewing the status and results of testing. SSE presented and successfully completed the Phase I SMART Review for the Crack Repair Material (CRM) at JSC on 10/26/04. SSE participated in the mishap investigation of the spill of ROCR material found in the lab. Preventive measures have been instated to prevent any similar event from occurring. Material testing continues to determine off-gassing characteristics of the material. SSE continues to raise concerns over the short preparation time and preparation environments for tests to support the down-select on 01/07/05. The preliminary result of recent material testing was positive and provided data to support the material down-select process.

SSE supported development, review, presentation and acceptance of multiple ET Hazard Reports and CILs. Support has included multiple presentations to the SSRP, the PRCB and the Shuttle CCB. SSE also coordinated fault tree tiger team efforts and tracked open testing necessary for close-out.

SSE supported the review and updating of documentation and presentation material for the ET Design Certification Review (CDR) I on 12/09-14/04, at the NASA Michoud Assembly Facility (MAF). The primary responsibility of SSE was to review the ten ET Hazard Reports (HRs) that were part of this review. The hazard reports were determined to be mature and acceptable.

SSE participated in weekly working-level discussions with ATK Thiokol concerning ply lifting, nozzle joint 5 enhancements, propellant grain characteristics in transition areas, ETM-3 impact mark, Yellow tape in RTV, etc. SSE supported the Nozzle Joint 5 Bolt Assembly Enhancement CDR held at MSFC 10/04-15/04, and the CDR Kickoff on 10/04/04 for the redesign and enhancements made to nozzle joint 5. SSE also participated in the TIM (MSFC 10/27/04) for the Aft Exit Cone Increase Ply Angle, for Flight Support Motor-12 only, discussing the new material and the change of wrapping angle to 23 degrees instead of zero degrees.

SSE participated in two reviews (10/4/04 and 10/5/04) of draft Shuttle Safety Review Panel (SSRP) presentation charts for downgrading five proposed Space Shuttle Main Engine (SSME) accepted risk hazard causes. SSE participated (10/26/04 and 11/03/04) in the SSRP reviews of one SSME hazard report update plus SSME responses to SSRP action items, concluding the series of SSRP TIMs for SSME RTF hazard report updates. The updated hazard reports will be officially released for MSFC, SSRP and PRCB approval. SSE participated (11/17/04 and 11/18/04) in the SSRP discussion of debris and the review of integration hazard report number IMPS-17 ("Inadvertent SSME Shutdown").

SSE has evaluated the SSME FMEA/CIL updates proposed for RTF, including 21 that provide controls for "accepted risk" hazard causes, plus a few FMEA/CILs that are being modified. Approximately half of the affected FMEA/CILs have been updated and the remainder will be completed shortly. SSE supported reviews of draft SSME FMEA/CIL updates for RTF (items B500-0201 and B500-0105) on 12/21/04 and 12/22/04, and continued evaluating draft copy of SSME Hazard Report RTF updates. SSE completed evaluation of three Systems changes; also, continued evaluation of five SSME changes and two Systems changes that were recently received for review.

SSE has begun updating the Safety impact assessments for current SSME technical issues in the new S&MA Technical Issues database, based on any additional information gained since they were initially generated.

SSE wrote the hazard reports for the ET Excitation Power Box (EPB), rewrote them according to comments from the EPB team, supported the CDR, and edited the hazard reports again according to comments in the Review Item Discrepancies (RIDs). SSE closed the related RIDs.

SSE supported the Exploration Systems Mission Directorate (ESMD) draft Level 1 System Requirements review efforts. SSE continued team support as lead & Point of Contact for S&MA. Assessments conducted during this period included review of the NPR 8705.2 draft revision and compare to the July draft System Requirements for the Crew Exploration Vehicle Launch System. Tasks included: develop parent traces to the new draft NPR and suggest new requirements or revisions to the current systems requirements as a result of the new draft NPR. A two-day meeting was held at MSFC to review all team assessments conducted during this period. The team continues to develop parent traces to the new draft NPR and suggest new requirements. SSE conducted an independent review of the all changes to verify all technical changes of the draft NPR where accommodated or identified as orphans.

SSE continued to support efforts to format, specify content, and define the overall approach and definitions necessary to create the manpower estimation tool for future Exploration S&MA tasks.

SSE began updating the draft Constellation Safety & Mission Assurance Plan, based upon comments. SSE also traveled to JSC, 12/12/04 – 12/16/04, to support the table top review of two Constellation S&MA documents: Constellation Safety Requirements, and the Constellation Hazard Analysis Methodology. The table top was completed successfully and SSE will be the acting POC for incorporating changes to these documents.

SSE reviewed Node 2 documentation, closed Safety Verification Tracking Log (SVTL) items and participated in the Nodes change control board. SSE reviewed multiple documents and document changes (including hazard reports) that affected the Nodes. SSE worked with the JSC ISS safety office to provide closure documentation to hazard report verifications for the ISS level integrated hazard analysis. SSE worked on providing completed copies of all hazard reports to the Nodes website and HEI payload safety drive.

SSE incorporated comments from subsystems into hazard reports and transmitted these reports to JSC ISS SRP coordination office. SSE completed updates to the remaining five (5) Node 3 hazard reports for the delta phase II review. SSE scheduled the Node 3 delta phase II review for 01/11-13/05 after incorporating all comments into the Hazard Reports and submitting them to JSC. SSE is updating Node 3 Hazard Reports for upcoming Delta Phase II Safety Data Package Review in 01/05. SSE has created a SVTL for Node 3. SSE is also reviewing SVTL for Node 2, to verify method of closure.

SSE supported the normal Multi-Purpose Logistics Module (MPLM) team meetings. Thermostat installation on Flight Module (FM) 1 has been completed with 20 thermostats and the data recorder. Initial testing shows that the installation was performed correctly. Final tests revealed two minor anomalies. KSC has generated a Problem Report (PR) and is working with ALTEC and the MPLM Project to resolve them.

SSE updated MPLM / Orbiter Integrated Hazard Report MOI-7 to account for the Extra Vehicular Activity (EVA) stay-out zone around the Remotely Operated Electrical Umbilical (ROEU) connector. S&MA and the MPLM Project are currently negotiating with the Payload Safety Review Panel (PSRP) to determine the best approach for solving this problem. SSE made additional updates to the Flight LF-1 MPLM/Orbiter Reflight Assessment. The MPLM Project signed it and submitted it to the PSRP for approval. The Flight LF-1 Payload Integration Manager (PIM) made comments on Hazard Report MOI-7, so the project has edited the report and sent it back out for final comment. This report is expected to be submitted to the PSRP next week. SSE also made additional updates to the Flight LF-1 MPLM/Orbiter Reflight Assessment.

SSE conducted follow-up activities to the Functional Configuration Audit (FCA) of the Oxygen Generator System (OGS) Oxygen Generator Assembly (OGA) at Hamilton Sundstrand. SSE reviewed a total of twenty-five (25) verifications, including twelve (12) previously reviewed. Twenty-four (24) verification packages were approved and one (1) was disapproved. An action item was written to correct the disapproved data package. SSE continues to review OGS test procedures. SSE closed three (3) verifications for the OGA requirements related to separation of redundant paths, safety of ground testing at the operational location and meeting two-fault tolerance requirements. SSE also reviewed the verifications for each hazard control. SSE also reviewed four (4) test procedures.

SSE supported the Urine Processor Assembly (UPA) and Water Processor Assembly (WPA) team meetings. SSE also reviewed and commented on eleven (11) sets of test procedures and one (1) WPA verification package, also providing comments to QD30. SSE reviewed the thirteen hazard reports that make up revision J of the WPA hazard analysis. SSE updated the Water Recovery System (WRS) hazard analysis based on the changes made in the WPA hazard analysis and made updates to the WRS Hazard Reports based on comments received from the Project.

SSE supported several of the Environmental Control and Life Support Subsystem (ECLSS) Ground Support Equipment (GSE) meetings and provided comments where needed. SSE also provided safety information to the ECLSS project on the use of Swagelock compression fittings at KSC. SSE reviewed four Node 3 hazard reports for WRS information and provided the resulting comments to the Node 3 Project.

SSE supported the normal Biological Research Pack (BRP) meetings and the Station Problem Resolution Team (SPRT) Meeting. Fifteen Manufacturing Action Requests (MAR) were approved. Final DD250 of the Qualification Rack occurred on 10/29/04. The rack then went through Interface Requirements Document (IRD) testing the following week. No anomalies were reported during any of the IRD testing. Final DD 250 of Habitat Holding Rack 2 (HHR-2) occurred on 11/11/04. The BRP Project held a preship review for HHR-2 on 11/29/04, and determined that HHR-2 was ready for shipment. HHR-2 was shipped the next day and arrived at KSC on 12/1/04. HHR-2 completed post delivery inspection on 12/02/04 with only one minor discrepancy. KSC has issued a Problem Report (PR) to cover that. HHR-2 testing is expected in January. The BRP Project is continuing to work with KSC to refine the test schedule for HHR-2.

SSE supported the review of project-identified risks for the Materials Science Research Rack-1 (MSRR-1) to ensure that the development of each response included S&MA. SSE is preparing to support an extensive review of requirements to ensure they can be traced to verification. SSE received the PSRP's approval of the team's requested the safety review schedule. The MSRR-1 team plans to communicate with ESA on a schedule for review of sub-elements and the integrated rack when discussions at Headquarters clarify the future of MSRR-1 and its sub-elements. SSE coordinated a TIM with the PSRP on 10/28/04 to review the design approach for the Thermal and Environmental Control Shelf (TECS) over-pressure protection plan. The PSRP approved the design approach.

SSE continues to support the Quench Module Insert (QMI) Test Requirements Matrix review. SSE is reviewing safety-related tests to ensure traceability to requirements and to ensure accuracy and validity.

SSE provided a flammability assessment to the Microgravity Science Glovebox (MSG) Lead Systems Engineer (LSE). In discussions with the NASA PM and LSE, it is likely that the lacing tape will be used as-is with ESA emails citing the ESA/NASA Interagency agreement serving as documentation of its use. SSE researched the disposal of an MSG Video Drawer Battery Pack in the Progress automated vehicle. Cargo safety and manifesting issues are currently being worked with help from the MSG PSRP contact. SSE participated in review of SSP 57211, MSG hardware Interface Control Document (ICD).

SSE participated in review of MSFC-RQMT-2888E, MSG Investigation Interface Requirements Document. Verification of safety-related items occurring during real time operations will be included in the 2888 Verification Matrix, while others will be tracked using the Safety Verification Tracking Log (SVTL). SSE wrote a presentation on "Crew Surveillance Requirement for MSG Combustion Investigations," incorporating team comments. Crew surveillance is a requirement of MSFC-RQMT-2888 (MSG IIRD), although the higher level NASA standards (57000, 1700.7, 1700.7 ISS Addendum) and ESA documents do not require it. SSE and members of the MSG Integration Team briefed the PSRP via telecon and recommended the removal of the requirement. The PSRP concurred, with the understanding that crew surveillance may be required for combustion investigations on a case by case basis through the Phased Safety Review process. SSE participated in the MSG Level III CCB that approved inclusion of the MSFC-RQMT-2888 verification review/approval matrix into the MSG Data Management Plan. SSE participated in review of the latest revision to the MSG S&MA Plan as it relates to the non-conformance process.

SSE observed procedure test operations for the Shear History Extensional Rheology Experiment (SHERE) in the MSG Engineering Unit. SHERE has requested permission to operate without gloves for certain aspects of their experiment due to size and intricacy of the hardware that must be manipulated inside the MSG Work Volume. The only outstanding issue is the slight possibility that sample fluid (toxic hazard level 0) could leak from the experiment into the MSG Work Volume, leaving a sticky residue. The MSG LSE has approved the use of peanut butter to clean up leaking sample fluid, after

demonstration of its feasibility in the MSFC MSG Locker. SHERE is currently not included in the manifest for the ATV1 flight.

SSE participated in the Boiling Experiment Facility (BXF) Phase II presentation to the PSRP via telecon.

The Project Plan and S&MA plan for Gravitational Effects on Distortion in Sintering (GEDS) are now under review by S&MA. The GEDS project manager has acknowledged their urgency. The RDR/SRR schedule is still not fixed, owing to NASA Headquarters priorities for science projects. SSE participated in risk management efforts for the GEDS project, which emphasized that the lack of an ICD for the MSL/LGF from ESA could affect GEDS Thermal Probe schedule and cost adversely. The S&MA lead was tasked with determination of steps required to qualify the MSFC Mellen furnace for vacuum bake-out of the SACA flight hardware. This information along with a furnace buy/outsource study by GEDS Test Engineering will be used to find the cheapest alternative for the vacuum bake-out effort. SSE/S&MA participated met with the GEDS project team to discuss experimental verification of the sample mass loss rate from GEDS crucibles. The team agreed that toxicity level of "0" is appropriate based on the experimental evidence compared to Spacecraft Maximum Allowable Concentration (SMAC) values. The GEDS project scientist will document these results and communicate them to the PSRP toxicologist directly. A revised HMST will be solicited from the JSC Toxicologist.

SSE wrote a letter to the PSRP for the In Space Soldering Investigation (ISSI) project team, stating that the existing hazard analyses cover plans to return ISSI coupons to earth.

SSE supported planning for continued development and testing of flight software to resolve minor issues with the execution of commands for the Glovebox Integrated Microgravity Isolation Technology (g-LIMIT).

SSE analyzed gaps Center & Directorate level requirements for software safety in response to a Centerwide Action item Tracking (CAIT) action request. The analysis determined if the Center fully, partially, or failed to comply with each requirement of NASA-STD-8719.13B. The results were submitted to QD40 on 11/05/04.

At the request of QD40, SSE used a System Safety Basics Presentation to fill in for the planned System Safety Module in the "Foundations of Project Management" course on 11/18/04. The course focused on the roles and responsibilities of the System Safety efforts in any MSFC project or program. SSE has recommended to QD40 that MSFC S&MA provide the information for any S&MA module that is part of a training course used here, so that S&MA can assure that the module reflects MSFC S&MA functions and properly relates to the subject matter and audience.

## **4.2 Reliability**

### **4.2.1 Reliability & Maintainability Engineering (R&ME)**

During 1<sup>st</sup> Quarter of Fiscal Year 2005 Reliability and Maintainability (R&ME) continued to support the JIMO (Prometheus) Program by studying available documents to determine areas of interest or concern in order to help direct search for relevant lessons learned. Such information was captured and published in the JIMO (Prometheus) Lessons Learned New letter each month until the last submittal in 10/04. R&ME received comments to the JIMO (Prometheus) TBR 2 System Level Fault Tree and incorporated them in the Fault Tree.

R&M continued to work on the TBR 2.5 Fault Tree meeting with HEI, TPI, and JPL Fault Tree Team members at MSFC in order to discuss the new Fault Tree quantification tasks for the JIMO (Prometheus)

Program. The result of this meeting was a Preliminary Fault Tree Analysis developed for the 2.5 mission on Deployable Hardware and Marshall Hardware that was delivered to the JPL Fault Tree team during this reporting period. This effort was conducted in order to status the development of the trees and to determine the logic progression of the Fault Tree quantification effort. The following Preliminary Fault Trees were delivered to JPL for the 2.5 mission quantification effort: Thermal Control System, Docking Adapter System, Spacecraft Cabling, Propellant Storage Assembly and Deployables.

R&ME continued providing support to the TR107 LOX/RP1 Engine by reviewing and discussing the latest FMEA on the TR107 LOX/RP1 engine. R&ME attended the TR107 Risk Reduction Project, Design Process for Reliability, Maintainability, and Supportability final review in order to provide questions, comments and concerns on the coking analysis.

R&ME supported the Constellation Program this quarter by meeting with the program's team members in order to ensure that all R&M program requirements and manning needs (FTE's) were identified and listed accordingly for FY05. Additional R&ME support provided to the Constellation Program included developing identified documents for defining the program's requirements and deliverables for the Reliability, Maintainability and Supportability functions and FMEA/CIL Methodology. A draft of each of these two documents have been provided, reviewed, discussed and revised with MSFC and JSC Constellation Program Team members, during table-top reviews, for the pending purpose of incorporating them into the program's S&MA plan. Proposed DRD's and the Analytical Consistency Plan were also reviewed, with comments provided, as well as reviewing the latest Human Rated Launch Vehicle (HRLV) Requirements Team's documents and changes, in order to provide applicable comments as required to the Reliability sections of the documents.

R&ME continues to provide dedicated support to Return-To-Flight activities as well as day-to-day activities by thoroughly reviewing all current SRB, RSRM, SSME and ET Critical Item Lists (CILs) and potential CILs for retention rationale pertaining to the Space Vehicle Assurance Group/QD20. In addition to reviewing numerous CILs, R&ME also participated in several Preliminary Requirements Reviews (PRRs), Preliminary Design Reviews (PDRs), Critical Design Reviews (CD's), Design Certification Reviews (DCRs), TIMs and audits for new hardware designs, redesigns and technical issues such as; SRB Element's Single Mission Fuel Isolation Valve (SMFIV) 90 degree Backshell Connector, SRB Element's Maintenance Audit on BST Batteries, SRB Element's Silver Zinc Batteries, RSRM Element's Case Component Master Verification Matrix Review, RSRM Element's Corrosion Issue, RSRM Element's RT 455 Application on Stiffener Ring Spice Plate Joints Issue, RSRM Element's O-Ring Resiliency Testing, ET Element's LO2 Feedline Bellows Ice Elimination, ET Element's Enhanced Launch Vehicle Imaging System (ELVIS), ET Element's Instrumentation, ET Element's Excitation Power Box (EPB), SSME Element's Agenda and Action Item Tracking Log for System Safety and Reliability, SSME Element's Combined Hot Gas to Fuel System Leak Check OMRSD Update, SSME Element's VCR LS821-1. R&ME also conducted a Process FMEA (P-FMEA) on the SSP's RCC (part of the Thermal Protection System (TPS)) composite repair material (CRM) which is designed to allow on orbit repair of damaged RCC panels and updated RSRM's Reliability and Maintainability Organizational Instructions (OIs) along with several R&M related Standard DRD's for Configuration Management review and implementation. The OI update is an annual update consisting of reviewing and revising/updating six Reliability OIs and five Maintainability OIs.

R&ME continues to provide dedicated support to two of the International Space Station (ISS) Program's projects; Material Science Research Rack (MSRR-1) and NODE 3. Support to MSRR-1 was through the review and comments of the Solid State Power Controller Module (SSPCM) Failure Modes and Effects Analysis submitted by Boeing. One of the comments was that Boeing had not classified any of the failure modes as causing mission loss to the Material Science Research Rack (MSRR-1). R&ME identified the SSPCM failure modes that could cause mission loss to MSRR-1 and provided those to Boeing. Boeing

agreed to identify those failure modes as leading to MSRR-1 mission loss in their FMEA worksheets. R&ME also revised the MSRR-1 Limited Life Items List based on the comments received from an internal review. The limited life items (LLI) worksheets in the document have been updated to make them complete and consistent. Part numbers have been included for all the MSRR-1 LLI, with editorial and other changes being made to the narrative portion of the document. This revised document will be sent out for another round of review before baselining the document. R&ME's latest efforts are revising the MSRR-1 Master Controller Reliability Prediction based on the updated parts list. The prediction data is according to the MIL-HDBK-217 Notice F Part Stress Analysis.

R&ME continued finalizing the Node 3 Failure Modes and Effects Analysis/Critical Items List (FMEA/CIL). During this period, FMEA/CIL worksheets for the Node 3 Fire Detection Subsystem were signed off by the Nodes Project Office and formally submitted to ISS R&M for incorporation into the ISS FMEA/CIL.

R&ME continued as an active member of the Space Shuttle Program (SSP) Reliability and Maintainability Working Group and the International Space Station (ISS) Reliability and Maintainability Panel, held jointly each week with Johnson Space Center (JSC) to ensure that R&M programmatic and technical requirements are implemented within each program. Beginning with 1<sup>st</sup> Quarter Fiscal Year 2005 R&M Engineering was given the task of providing a weekly status of R&M risk items to the SSP's S&MA Working Group.

R&ME continued to provide support to Industrial Safety (QD50) by meeting and discussing with them crane assessments. NASA-STD 8719.9, "Standard for Lifting Devices and Equipment" requires that a safety analysis be performed on all cranes used for critical lifts. Industrial Safety provided QD50 with an explanation of the current analysis process developed by HEI using a generic analysis performed to cover all critical lift cranes with Hazard Analysis Closure Sheets (HACS) derived from the analysis to close specific hazards with each individual critical lift crane. The process information for review was received as well as an action item to review crane specifications in order to ensure all requirements for critical lift cranes are included.

R&ME training and knowledge enhancement of the Space Shuttle Program (SSP) remained active during 1<sup>st</sup> Quarter Fiscal Year 2005. R&ME training included: SSP Top Risk Reporting (TRR) for identifying and escalating risks to the proper level for review; SSP Risk Management Training that demonstrated how to write risk statements with supporting context, analyzing the risk using the SSP Risk scorecard and the use of the SIRMA to document, track, mitigate and report concerns and risks; Human Factors and Process Failure Modes and Effects Analysis (HF&P-FMEA) Class for performing detailed tasks analysis and complete HF-PFMEAs; Certificate of Flight Readiness (CoFR) Process Training – Parts A and B that ensured a basic understanding of RSRM processing and design; ATK Thiokol Performance Enterprise System (PES) Training on how all disciplines can improve quality, reduce cost, eliminate waste and improve the health, safety and environment of employees; Root Cause Analysis Training on understanding root cause concept, identifying them and how to formulate corrective action; R&M Discipline Training through QD40 on implementation, policies and application of Reliability, Maintainability and Supportability on current and future NASA programs and projects.

#### **4.2.2 Problem Assessment Center Operations**

HEI's PAC personnel processed and coordinated disposition of problem reports; coordinated the MSFC Problem Assessment System; coordinated problem processing; participated in an STS-114 countdown simulation; coordinated MSFC actions regarding implementation of NSTS 08126 Revision J "Shuttle PRACA Requirements", and operated the Corrective Action System (CAS). The PAC received and entered 40 new problem report (PR) into MSFC's Problem Reporting and Corrective Action (PRACA)

System, coordinated MSFC interim closure of 24 PRs, received 24 prime contractor closure recommendations, supported MSFC full closure of 23 PRs, coordinated non-problem closure of 19 problems, and performed 236 individual PR database updates and reviews. PAC conducted 8 SSME problem review boards (PRBs) resulting in dispositioning 37 of 39 problem reports presented, including maintained storage of supporting Unsatisfactory Condition Report (UCR) data on a common-access server and implementing a new design review cycle prior to bringing UCRs to the board. The PAC generated or updated trends for MSFC Shuttle problems submitted as newly opened and for closure. PAC also generated and distributed monthly problem bubble trend risk charts and briefed the charts at the monthly SRB Problem Assessment System (PAS) review. PAC reviewed 12 requests for access to the MSFC PRACA database and granted all of them.

In support of return-to-flight, PAC coordinated MSFC's response to follow-on actions resulting from the Revision J to NSTS 08126; obtained, consolidated, evaluated, and explained related contractor cost impacts; and evaluated and red-lined RSRM and SRB contractor plans to implement the requirement changes. PAC also assisted the Shuttle Projects in generating contractual direction to the contractors for this revision. PAC also revised the MSFC PRACA data system to be in compliance with Revision J by implementing two new data fields specified in the document.

The PAC provided various problem data in support of NASA and MSFC analyses. Regular activities included providing daily KSC PRACA shuttle problem summaries, daily MSFC PRACA open-against-next-mission summaries, daily KSC Resident Office reports, monthly newly opened/closed problem summaries, weekly SRB PRACA and ALERT activities and status reports, and quarterly Open Problems List (OPL). Special activities included: (1) provided SSME problem history data on LPOTP and LPFTP discharge duct flaws and duct buckling; (2) provided the SSME advanced turbopump contractor with listings of all the KSC SSME problem reports since 1995; (3) provided SSME problems related to engine installation handling in response to the Engine 2057 lifting incident; (4) obtained and provided listings of KSC PRACA reports on longeron frost during countdown; (5) provided full listings of active SSME turbomachinery problems to the SSME Project coordinator; and (6) provided QD40 planning, processes, and findings resulting from survey of contractor problem processing activities in 2001 and 2003.

In problem trending, PAC generated regular problem entry and disposition problem histories; issued monthly bubble trend charts with interpretations of data; and, in coordination with QD40 Reliability and QD20 Shuttle Assurance, defined and obtained approval of significant enhancements to make trending activities more useful in risk management. This included generating a prototype automated template to generate trend charts applicable to various PRACA database codes and performing numerous trends based on Symptom, Failure Mode, FMEA Failure Mode, Cause, and status.

In implementation and operation of the MSFC Corrective Action System (CAS), PAC received 38 potential CAS reports, screened 39 draft Recurrence Control Action Requests, elevated 1 to new Recurrence Control Action Requests (RCARs), coordinated 3 point of contact (POC) responses, and facilitated 4 Corrective Action Boards (CABs) resulting in closure of 4 RCARs. PAC also provided and discussed CAS metrics and open RCAR status reports at Marshall Management System (MMS) Implementation Team meetings, and issued monthly RCAR status and delinquent response reports. During the ISO surveillance audit, PAC was evaluated as having only one minor nonconformance regarding inadequate root cause isolation in some of our RCAR closures.

#### **4.2.3 ALERT Program**

HEI's ALERT support included both regular and special activities as HEI ALERT coordinated MSFC ALERT processing and participated in the NASA and general Government-Industry Data Exchange Program (GIDEP) activities. HEI received and distributed 31 ALERT announcements for MSFC review and obtained 2,443 responses from MSFC project, contractor, and laboratory contacts. HEI ALERT also

provided notification, assistance, and support regarding delinquent ALERTs resulting in a new low of less than 100 during the period. HEI ALERT support personnel: 1) reviewed and approved 6 new MSFC ALERT database accounts via the TPS security; 2) generated monthly Open, Delinquent ALERT response tabulations and provided them to S&MA and/or Directorate single points-of-contact responsible for open ALERT reduction; 3) obtained and distributed ALERT reminders at the annual Safety Day; 4) enhanced the data system to provide an standard report of ALERT closed over a user-specified time frame; 5) researched and statused ALERT activities regarding Inconel cracked bolts and an SSME filter capacitor incident at Stennis; and, 6) led activities of the Industry Advisory Group (IAG) of GIDEP as the IAG Chair by participating in monthly GIDEP Executive Committee telecons, generating articles for the quarterly newsletter, presenting and leading discussions at the October annual GIDEP clinic, and coordinating location of the February 2005 GIDEP Business meeting at Salt Lake City with ATK/Thiokol as the host.

### **4.3 Quality**

#### **Space Transportation**

Space Shuttle Main Engine (SSME) Quality Engineering (QE) evaluated numerous Program, Project and contractor changes for quality impacts, and has acted as the regular S&MA interface with the SSME Project regarding the recently completed High Pressure Fuel Turbopump Liquid Air Insulation redesign. QE also participated in an audit of the Rocketdyne Critical Items List validation effort performed to assess the appropriateness and proper implementation of SSME CIL accepted risk hazards.

SRB QE continued to support the BSM graphite throat Factor of Safety (FOS) tiger team meetings. QE continued to help develop and review numerous test plans for analytical validation. QE ensured proper coverage on fabrication of test articles, motor assembly and static test firings. QE reviewed progress of the material properties testing and analysis. QE reviewed preliminary statistical assessment of the new bondline evaluation technique. QE reviewed preliminary waiver information for Aft BSM FOS.

SRB QE continued day-to-day activities which included support to weekly Booster Separation Motors (BSM) Integrated Process Team (IPT) meetings, BSM Plume Characterization Team, RTF Action Review, and RTF TIMs. QE prepared and presented technical issue briefings to S&MA upper management.

SRB QE traveled to Pratt & Whitney (P&W) to support the Booster Separation Motor (BSM) Phase III acceptance reviews covering all hardware and paperwork on deliverable flight hardware. QE provided timely support for all BSM Phase II process and document development for new procedures. SRB QE reviewed documents and submitted Review Item Discrepancies in support of the BSM Redesigned Igniter Design Certification Review.

SRB QE provided support to the Automated Dynamic Acceptance Procedure Test Stand (ADAPTS). QE participated in the weekly meeting associated with test readiness review, open purchase order, open electrical tasks, open mechanical tasks, open procedures/ documents, drawing status, software testing requirement, and hardware verification requirement.

SRB QE participated in the SRB Bolt Catcher and NSI Pressure Cartridge Design Certification Review. QE completed the evaluation of X-Ray and N-Ray radiographic film for CDF Assembly Lot ACG deliverable and lot acceptance test units (353 assemblies).

SRB Pyrotechnics QE supported the NESC SRB Holddown Stud Hang-up ITA telecoms and the RSS S&A Device hardware inspection conducted at the Ordnance Storage Facility, KSC.

SRB Pyrotechnics QE supported the CDFA Lot ACG Phase III Review held at the Goodrich Universal Propulsion Company, 393 Lot ACG units were presented for the phase review team's assessment.

SRB Pyrotechnics QE was a member of the Pyrotechnics Review Team during the SRB Bolt Catcher/NSI-PC DCR held this reporting period. The team conducted an assessment of compliance to the certification requirements for the redesigned NSI-PC.

QE participated in Arc Jet testing of various specimens for the RCC On-orbit Crack Repair (ROCR) Task at Boeing and Ames Arc Jet facilities.

#### **Software Quality Assurance (SQA)**

Software Assurance (SA) participated in formal reviews for Orbital Express (OE) Inverse Perspective Algorithm. SA reviewed new revisions of OE Software Requirements Specification (SRS) and Boeing's Interface Design Description (IDD). SA reviewed OE Optical Characterization Testing Procedures. SA baselined version 1.0 and version 1.1 of OE code to be loaded on Engineering Design Unit (EDU). SA completed Software Traceability Audit for OE and EI32 Organizational Audits (Software Metrics Management; Software Configuration Management and System Administration). SA witnessed formal testing for Urine Processor Assembly (UPA). SA provided input for Constellation S&MA Plan.

SA completed Human Factors Process Failure Modes and Effects Analysis Course. SA attended Risk Management Conference held by Ohio Aerospace Institute in Cleveland, OH. SA participated in QD40 and QD10 staff meetings and monthly status reviews with S&MA management.

#### **ISO/AS9100**

QE has continued to play a key role in ensuring the maintenance of ISO 9001 and AS9100 at MSFC during this time period. Efforts have dealt with continuing implementation of ISO 9001 and AS9100, maintenance of documentation, and planning and support for the NQA registrar surveillance audit, including preparation of self-assessment checklists for the MSFC organizations, escorting during the audit, and follow-up and closure of corrective actions. QE provided general ISO and AS9100 support, including Marshall Quality Council (MQC) meeting preparation; reviews of both MSFC and NASA Agency documentation; and consulting support on internal audits and other aspects of ISO 9001 and AS9100 to various MSFC Organizations. QE continued to be involved with the NASA Headquarters rules review action, including participation in the focus team that set the ground rules for implementation and tracking by MSFC, assisting multiple organizations with review and revision of directives and organizational issuances, providing input on all directives to the S&MA Directives Control Board member, and ensuring ISO 9001 and AS9100 requirements were retained. QE is also providing support to the Environmental Engineering Department to assist with integration of ISO 14001 requirements into the existing Marshall Management System.

#### **Payloads**

QE performed drawing reviews, procedure reviews, test readiness review, and procurement reviews, inspection requirements, shipping requirements, and supported team meetings for ECLSS, GBM, MSRR, Solar-B, MSG and GEDS. QE reviewed and provided comments for safety verification closures for ECLSS. QE provided quality expertise to Material Review Boards for ECLSS, MSRR, g-LIMIT and MSG.

QE participated in the Technical Interface Meeting (TIM) held at MSFC for MSRR-1 and GEDS with personnel from the European Space Agency (ESA) concerning options for completing both projects. QE reviewed and commented to submittals of the Acceptance Data Package (ADP) for the Wastewater Storage Tank Assembly (WSTA) book I & II for Environmental Control and Life Support (ECLSS).

QE reviewed the workmanship vibration test plans for the Thermal and Environmental Control System (TECS) shelf and Vacuum Access System (VAS) shelf for MSRR-1.

QE participated in the review of the ICD for the GEDS Thermal Probe. In addition, QE participated in the review of the GEDS toxicity discussions and ways to mitigate the toxicity concerns for the experiment. QE developed Memorandums of Understanding (MOU) with Teledyne Brown Engineering (TBE) involving the completion and approval of thermocouples and cartridge heads for GEDS.

QE reviewed and provided comments for the baseline of the Shelving Plan for the OPCGA hardware.

QE performed drawing reviews, procedure reviews, test readiness review, and procurement reviews, inspection requirements, shipping requirements, and supported team meetings for ECLSS. QE reviewed and provided comments for safety verification closures for ECLSS. QE provided quality expertise to Material Review Boards for ECLSS. QE conducted a second Functional Configuration Audit (FCA) of the ECLSS Oxygen Generator Assembly (OGA) at Hamilton Sundstrand in Windsor Locks, CT.

### **Inspection and Test**

Quality Assurance (QA) personnel supported the ET / SRB RTF testing and inspection activities. QA personnel performed dimensional inspections and witnessed the assembly of the SRB / NSI Retention Device and Pressure Cartridge, Forward and Aft Separation Bolts for the Structural Factor of Safety Qualification test at the Pyrotechnic Lab; the NSI Retention Device and Pressure Cartridge Structural Factor of Safety post firing pressure qualification testing of the Forward and Aft Bolt Assemblies at the High Pressure Testing Facility. QA witnessed the bolt-drop qualification performance test and performed dimensional inspection of the Bolt Catcher Energy Absorber; the vibration and acoustical qualification testing of P/N 10175-0020-101, ET / SRB Bolt Catchers, Energy Absorber Material, and Bolt Catcher Machined Cork Recertification Test Panels. QA witnessed Modal testing of the manipulator arm attachment hardware. QA is currently supporting the bonding of Booster Separation Motor Throat Assemblies per USA Test Plan SAPL-02391-2004.

A Quality Engineer for the Test Area was responsible for the removal of the Northrop Grumman Composite tank. QE for the Test Area was responsible for the review, revision, release of procedures, and testing of the RTF Hydrogen Bipod Heater and Control System. QE reviewed and released work authorizing documents for the RTF Bipod Hydrogen Heater and Control System and the Nozzle Impact Testing. QE monitored the build up of the facility for the Nozzle Impact Testing.

Test Area Quality Assurance (QA) personnel performed visual weld inspections and Non-Destructive Evaluations (NDE) on the completed portions of the Cryogenic Liquid Level Sensor Test Vessel and related components. QA personnel performed weld inspections on the completed portions of the new facility gaseous hydrogen (GH2) piping being fabricated for Test Stand 115. QA performed Non-Destructive Evaluations (NDE) on two modified injector housings for the Monopropellant test article at Test Stand 115. QA personnel completed the NDE requirements on the 24-inch Solid Motor thrust reaction structure at the Solid Propulsion Test Facility (SPTF).

QA personnel monitored the final three tests of the first series of the KT Engineering (KTE) thruster. QA personnel then monitored the removal and disassembly of the test article, and also assisted the KTE test requesters with visual inspections of the injector face as well as dimensional measurements of the combustion chamber and exit nozzle components.

QA personnel performed a baseline of the mechanical drawings for the recently installed facility systems interface for the Monopropellant test article at Test Stand 115.

QA personnel began baselining the Test Stand 500 Test Laboratory (ET) facility mechanical drawing package per ET11 request. The KT Engineering (KTE) and 24-inch solid fueled motor High Pressure Grain Test (HPGT) test positions were completed first.

QA personnel monitored testing of the Solid Fuel Torch in Test Cell 104. The objective of the series is to evaluate the Ply Lifting phenomenon in the convergent cone section of the Solid Fuel Torch.

Testing of the 24-inch Solid Motor High Pressure Grain Test (HPGT) series began with gaseous nitrogen (GN2) flow tests through the Test Stand 500 facility piping and the test article forward dome only. Two successful flow tests took place and were monitored by QA personnel.

QA personnel monitored testing of the Monopropellant test article at Test Stand 115. QA support activities included maintaining surveillance during removal, reconfiguration, and installation of the test article; monitoring test operations; and performing video borescope inspections of test article hardware between tests.

QA personnel monitored checkout tests of the lamp bank heater assembly in the 12-foot diameter vacuum chamber at Test Stand 300. These tests are being performed to verify the facility is functioning properly prior to installation and testing of the ET RTF 3' by 5' test panels.

Quality Personnel have provided coverage of the Hot Gas Facility in testing of Solid Booster Thermal Protection System foam and cork panel coupons. These test included the testing of Butyl Glycidyl Ether (BGE) reactive diluents to confirm that it will not adversely be affected due to a manufacturer change and change in location. QA monitored the testing of Aged Cork for the TPS of the SRB. This test has been run to validate that cork TPS has not changed due to expiration of shelf life.

Quality personnel monitored testing at Test Cell 103 of the 11" Hybrid Motor. The primary test objective of this 11" motor is to evaluate if the potential designed test bed can replicate particle impingement in a solid rocket motor environment. The motor was fired successfully.

QA personnel supported the Environmental Control Life Support Systems (ECLSS) Project with inspection and data review activities; including, inspecting/reviewing of work orders and data for the Distillation Assembly (DA) and the OGA Rack Assembly. QA personnel witnessed functional testing of the DA and several non-conformances were initiated. QA personnel inspected/reviewed work orders and data for the Vacuum Access System/Avionics Shelf Assembly, and non-conformances were noted and a DR was initiated.

Receiving inspection was performed on hardware for multiple flight projects, assuring compliance to all requirements.

#### **4.4 Information Management (IM)**

During the quarter, Information Management (IM) incorporated numerous self-initiated improvements as well as requested modifications. The S&MA website, which was revised to resemble the NASA homepage, was modified to provide a common framework for use by other applications. Several applications, such as S&MA's integrated login and Travel, were revised to incorporate the common framework. The modification reduces maintenance necessary to incorporate standard changes. S&MA's integrated login application was also modified to improve account maintenance capability. Automated reports for number of days since last access and number of days since password change as well as an interface to easily suspend access were developed to assist in implementing security requirements. A Marshall Operational Readiness Review (MORR) was completed for the Audit Tracking Information

System (ATIS), which was deployed and subsequently modified to assign clauses to organizations, add additional reporting and charts, and modify for the new organization structure. IM completed the first phase of the Statistical Tool for Assessing the Risk of Space-exploration (STARS). IM produced a Safety, Health and Environmental Corrective Action Item Tracking System (SHECAITS) application for use by the SHE team; modifications are on-going. IM also produced applications for managing Shuttle delegated agency data and for managing on-site Shuttle resources. Other application revisions included significant changes to the Audited Vendor List/Limited Vendor List and Project Specific Vendor List; completion of the SHEtrak Inspection Schedule Module and a quick search for buildings; improved notification in the Acute Launch Emergency Restraint Tip (ALERT) System; recoding of the Space Flight Awareness (SFA) application to fit the common framework and to improve functionality; reporting by charge code in Travel; and continued modification of the Shuttle Action Item Database (SAID).

The Problem Reporting and Corrective Action (PRACA) system rehosting was completed as a cost-savings measure. The PRACA application was also modified to create a custom report and to incorporate numerous improvements. IM modified and deployed the Safety Day 2004 site. A draft document to describe MSFC's process for managing Lessons Learned was provided for review and new lessons were incorporated. Data was provided in support of the Incident Reporting Information System (IRIS) and meetings with IRIS sponsors and developers were supported. The IRIS interface was revised due to revisions in the IRIS database. Three S&MA security plans were revised and Patchlink, which reports status of required security updates, was incorporated on S&MA servers. IM coordinated changes to all aspects of the SSWP application due to effects of the center's reorganization on existing organization, supervisor and personnel data. IM designed a method of integrating access to SHE reporting processes; the revisions will be incorporated by 06/05. In addition, several IM personnel received training in products and in web security.

#### **4.5 Human Exploration and Development of Space (HEDS) Assurance**

The independent assessment management information system database currently in development for use in the Independent Assessment Group was presented to the IA group members in a training/development session. Recommendations made during the meeting are under consideration and appropriate changes will be made to the database.

##### **4.5.1 International Space Station (ISS) Independent Assurance**

Activities for International Space Station Independent Assurance were very limited during this period; resources were focused on Shuttle RTF efforts

##### **4.5.2 Space Shuttle Independent Assurance**

Independent Assurance (IA) submitted an Engineering Information Report (EIR) on the SSME RTF Design Certification Review (DCR) to the MSFC S&MA IA Manager. In this report, IA made nine observations that were transmitted to the SSME Project Office. Although the project has made substantial progress towards achieving design certification, much work remains to be completed as evidenced by open work relative to project actions and anomalous engine conditions. IA will also continue to track and assess this progress through completion of the DCR process.

IA participated in the Space Shuttle RSRM Project Design Certification Review (DCR) Kick-off held on 10/14/04–10/15/04, at Marshall Space Flight Center. Its purpose was to review the Design Certification activities which have been performed to demonstrate and validate the flight worthiness of the RSRM for use in RTF of the Space Shuttle Program. The Project level DCR process for the RSRM was initiated at this kick-off and continues with a DCR Pre-board and a DCR Board. IA had a few minor concerns with the presentation that were discussed with the S&MA RSRM representative. These were transmitted to the RSRM Project Office as Action Items/RIDs and should be addressed prior to the Project DCR. None of the concerns were return-to-flight constraining, but will enable the project to better assess the actual status

and to communicate that status to the Program. IA will also continue to track and assess this progress through completion of the DCR process.

The Independent Assessment of the Procurement Quality Control at Lockheed Martin has been completed. Fifteen findings and 40 Observations were identified during the assessment. The formal out-briefing is to be scheduled by MSFC.

MSFC IA Team members participated in the Tiger Team mid-term meetings for Independent Assessment of KSC GSE that interfaces with SSP flight elements, #KMJ-3011. These meetings were held at KSC on 10/26/04 and 11/03/04. The meetings were chaired by the SSP SE&I Manager with assistance from the MSFC PSE&I manager. Approximately 45 representatives from JSC, MSFC, KSC, USA, NESC, etc. were in attendance at both meetings, and the status and activities of the Tiger Team were presented and discussed by the entire forum. The members of the IA Team were encouraged to ask questions and to participate in discussions, and were provided additional data in support of activities completed or in work. A detailed list of actions assigned will be provided to attendees. At this point, specific data, procedures, tests, etc. are still out-standing and must be addressed prior to "Return to Flight". A time-line is also required to ensure that specified activities are accomplished within time limits.

IA participated in the SSME SSRP and PRCB reviews held on 10/22/04, 10/29/04, and 11/03/04. These reviews were in response to the CAIB "Raising the Bar Initiative (SSP-4)" action. Their purpose was to validate that the controls are appropriate and implemented properly for: accepted risk hazards, any hazards that warrant review due to working group observations, or fault tree analysis. A total of 12 "accepted risk" hazards were identified. Two accepted risk hazards have been eliminated because we no longer fly the engines that they were applicable to, one has been downgraded to "controlled risk" and nine remain unchanged. The causes associated with each of the accepted risks will continue to be studied to see if they can be downgraded. Every cause of an accepted risk must be downgraded before the accepted risk can be downgraded to "controlled". IA will continue to track and assess this process through completion.

A TIM was held at the MAF on 10/20/04-10/21/04 to discuss the strategy and supporting data for achieving flight certification of the ET flight hardware (ET-120 and subs). IA participated in TPS TIM-II and has prepared Engineering Information Report (EIR) documenting the results and providing observations and recommendations.

IA was requested by the Independent Technical Authority (ITA) to participate in a technical assessment of the ET foam characterization by Lockheed Martin at the MAF. This was initiated by the IG Office because of allegations made against LM by an ex-employee. The technical assessment has been made and the team concluded that the LM/MAF test laboratory personnel are following the proper procedures and all the procedures are in accordance with industry standards. All the test equipment appeared to be calibrated and operating properly. The team witnessed no frost or ice formation on the test specimens as was alleged. The team's assessment was reported to the Office of the Inspector General for their disposition.

Subsequent to attending the second TIM to review the strategy and status of the ET Thermal Protection System (TPS) certification, the IAT completed an Engineering Information Report which provided an evaluation of this effort. This report provided a summary of the TIM with concluding observations and recommendations. The major recommendation suggested that an additional TIM be held prior to the DCR to allow the review community insight into the results from rapidly maturing data. Additionally, the IAT concluded that for the Fly-as-is manually sprayed areas, neither design certification nor flight hardware certification can be achieved according to the classical definitions for certification. The IAT recommends that a waiver be generated with appropriate supporting flight rationale along with a

quantified risk to safety assessment and this data be presented to the Space Shuttle Program management for a decision on the proper course of action.

IA is monitoring the SSME nozzle ablative testing in progress at MSFC. The nozzle ablative material is presently installed on engines in positions 2 and 3 in the area that is impacted by air flow around the body flap during reentry. The current design consists of pre-molded panels that are attached to the aft manifold using a silicone adhesive. Evidence has shown that some of the ablative comes off during every mission. A new design where the ablative material in the uncured state is applied to the aft manifold and allowed to cure is under investigation. Testing on the new design under simulated ascent, on orbit, and reentry heating conditions, shows that it does not simulate the ablative failure mode, based on flight experience. The testing results are inconclusive and the comparison between the existing design and the redesign can not be correlated. This investigation will continue to try to understand these inconsistencies.

The SRB Level III Design Review was conducted at MSFC on 12/13/04-12/14/04. An EIR has been prepared. There were no significant issues.

A SRB Boltcatcher DCR Delta Board was required because of actions assigned during the DCR board. The action that was assigned to close out the single outstanding RID required USA to perform an analysis to determine bondline factor of safety (FOS) of the cork insulation material on the Boltcatcher housing. The analysis satisfied the RID originator, and the RID was forwarded for closure.

#### **4.6 Project Assurance**

Project Assurance Engineering (PAE) supported QD10 by performing numerous tasks associated with Exploration Systems Mission Directorate (ESMD) initiatives. In the area of Heavy Lift Cargo Launch System Alternative Maturation, PAE attended a one-week Probabilistic Risk Assessment (PRA) workshop held in Cleveland, Ohio. The workshop served two important functions: The basic understanding of the principles and composition of a PRA and second, presenters identified the areas of emphasis that NASA Headquarters is expecting from the centers when they do a PRA. In addition, PAE compared the data collected from Task 5 and the Heavy Lift Cargo Launch Systems, and which was presented to NASA Headquarters, to identify any potential gaps and visible trends. This will assist in gaining better understanding for future exploration work.

PAE evaluated the data collected from Task 5 and the Heavy Lift Cargo Launch Systems, to identify any potential gaps and visible trends. This assisted in gaining better understanding for future exploration work.

PAE also attended the Expendable Launch Vehicles Payload Safety and Mission Success conference held in Santa Barbara, CA, the week of 11/15/04. The conference attracted over 200 attendees from NASA HQ, KSC, JSC, JPL, GSFC, MSFC and major space vehicle contractors. Keynote speakers included Mr. Sean O'Keefe (pre-recorded message), Mr. Bryan O'Connor from NASA HQ, General Eugene Tattini, NASA JPL, and Mr. Paul Kirkpatrick, KSC, who was the conference Chairperson. The conference tackled many subjects which included NASA and USAF S&MA Policies, NASA Safety Requirements, S&MA Lessons Learned, Mission Assurance, Orbital Debris Assessment, Probabilistic Risk Assessment, Emergency Preparedness and Contingency Planning and other related topics. The conference was successful in that it focused on the critical path that NASA faces today and each individual's responsibility and contribution for shaping the planned NASA of tomorrow. The dialogue between the panel members and the attendees provided for honest and open discussions on the concerns that the NASA community had and the possible solutions to overcome known obstacles.

Also supporting ESMD initiatives for QD10, PAE prepared a draft of the Constellation Safety & Mission Assurance Plan. This plan, and the Constellation requirements documents related to Reliability, Maintainability and Supportability; Quality Assurance; and Safety and Software Assurance will form the basis for the NASA Headquarters Constellation S&MA Plan and requirements. Subsequently, PA engineers and other team members from MSFC traveled to Houston for a table-top review of the Constellation S&MA Plan. In addition to MSFC, JSC and KSC personnel were also at the review. The review was very productive in that it brought the document close to its final draft stage with the approval of all major players at the various NASA Centers. The Plan will be updated with the comments provided and will be sent out once more for review and comments before forwarding it to a technical writer for formatting and editing.

PAE has expended significant efforts under QD10 performance Risk Management planning for ESMD at the directorate level and for the Constellation program. PA engineers attended the Risk Management Conference V held in late October in Cleveland, OH and used information gained therein in subsequent drafting and preparation of risk management plans for both ESMD and Constellation.

PAE acted as a critical link among the risk management planning efforts of ESMD, Constellation, and Crew Exploration Vehicle (CEV) ensuring maximum coherence between and among the planning efforts. CEV efforts involve definition of risk management language required for the CEV Request for Proposal (RFP).

Following extensive pre-coordination, PAE presented the Constellation Risk Management Approach to the Constellation Integrated Discipline Team (IDT) Workshop on 11/30/04. The PAE attended the workshop on 11/30/04 through 12/01/04.

PAE then completed and delivered the review cycle draft of the Constellation Systems Risk Management Plan. The plan was delivered 12/16/04. It is now placed into the collaborative review environment. Prior to delivery of the plan, PA engineers reviewed the latest draft of the ESMD Program Managers' Handbook for drivers to the Constellation Risk Management Plan and attended Systems Engineering and Integration (SE&I) Integrated Discipline Team (IDT) meetings and the overall Constellation Systems IDT telecons. Work on creating a Constellation risk baseline has begun.

PAE reviewed and tentatively approved a Project submitted Safety Hazard Analysis and Risk Assessment related to both vertical and horizontal testing of the Aerojet RCE (Reaction Control Engine) at the White Sands Test Facility (WSTF). Testing in either configuration presents unique issues/concerns but the primary concern is that while in the horizontal configuration, residual propellant in the manifolds and or chamber could ignite, resulting in a "hard start" similar to that experienced during Option 1 testing at the Aerojet facility. A "hard start" of this type could propagate throughout the engine resulting in engine structural failure and valve and instrumentation damage. Among the controls being considered are: 1) testing in simulated altitude conditions to facilitate flashing off of excess propellant; 2) use of purge systems to fully evacuate the manifolds; 3) avoiding duty cycle ECWs (Electronic Coast Widths) too short in duration; 4) to provide adequate time for full evacuation purge; 5) running a 5-second warm-up pulse to facilitate flashing off of propellants; and, 6) avoiding short duration duty cycle EPWs (Electronic Pulse Widths) which could preclude detection of established redlines. Final approval is pending completion of analysis to determine the optimum duration for duty cycle EPWs. Concurrence will be required by Project Management and S&MA representatives from MSFC and JSC/WSTF.

The primary objective of this effort was to demonstrate a credible, transparent, repeatable, process for a design capable of effectively supporting the risk management process while simultaneously supporting engineering trade studies and the overall design process. The scope of this effort was limited to the Oxygen Rich Pre-Burner (ORPB) on the TR-107, 1 million pound thrust LOX/RB concept engine. As

presented, this process demonstrated the capability to significantly reduce the cost of maintenance and support through the elimination of failures early in the design process. Success of such working tools is dependent upon sufficient funding and getting full program/project management support early in the design/development process.

PAE represented S&MA at the Integrated Powerhead Demonstrator (IPD) Peer Review held at the Marshall Institute on 11/17/04-11/18/04. Although this is an Air Force Research Laboratory (AFRL) managed contract, MSFC maintains technical oversight with PAE serving as a consultant on S&MA related issues. The review, attended by representatives of the various technical disciplines from MSFC, SSC, Rocketdyne, Aerojet and the AFRL, began with a summary of project history and included detailed overviews of the top level test requirements, engine and major components, known and accepted risks, test plans, facility capabilities and the overall Risk Management Process. PAE's role was to address questions related to hardware MR (material review) dispositions, engine failure modes/hazard analyses and facility related safety concerns. IPD engine testing will be both schedule and hardware constrained with approximately 18 engine tests anticipated. MSFC will actively participate in the data review process and any changes involving redlines or perceived risk of test will require approval of both MSFC and AFRL on-site representation. Many components are one-of-a-kind items so failure of or significant damage to any one item or system would likely result in termination of the project.

PAE has completed review of the third revision of the IPD Project's, "Incident Response Plan." The subject document, pending approval by AFRL, NASA-MSFC, and NASA-SSC, will be used in the event an incident occurs when testing IPD components, subsystems, and/or engine systems at SSC. As this is an Air Force Research Laboratory (AFRL) managed contract, the primary requirements were taken directly from existing Air Force Documents/specifications. The plan does, however contain requirements found in NASA-SSC Test Control specifications and Detailed Operating Procedures. Additionally the plan closely mirrors requirements contained in NPR 8621.1A "NASA Mishap and Investigation Policy." The plan originally referenced NPG 8621.1 but that document has since been replaced by NPR 8621.1A so Project Assurance suggested some language changes to reflect the most current version of the requirements document. Project Assurance also submitted comments related to test site S&MA responsibilities, investigative board membership, and reporting requirements. None of the comments are considered controversial and are expected to be approved.

PAE represented MSFC S&MA at Northrop Grumman's final presentation on the Design Process for Reliability, Maintainability and Supportability (RMS) held on 10/29/04 at MSFC. Topics presented included: 1) Process Design for RMS; 2) Classical Reliability Analyses; 3) Reliability Based Design Optimization; 4) Failure Mode Coupling; and, 5) Reliability Centered Maintenance Analysis. PAE supported QD20's efforts on the ET Development Flight Instrumentation (DFI) Relay Assembly Qualification and Acceptance Test Plan and Procedures by reviewing the plan and procedures for RTF. As part of the Bipod redesign, two Resistance Temperature Devices (RTD) will be installed on the Bipod web fitting. The Space Shuttle Program has directed that these temperature sensors be monitored until SRB separation. To accomplish this, the RTD circuits will be switched from the Ground Umbilical Connector Plate to the SRB Enhanced Data Acquisition System after liftoff. The relay assembly will perform the switch function. PAE reviewed the test plan and procedures and coordinated comments from Quality Control during a table top review. Further, PAE participated in the Test Readiness Review (TRR) for the DFI Relay Assembly testing and reviewed changes in the procedures to ensure that the facility and test article were ready for test operations.

PAE participated in a Problem Reporting and Corrective Action (PRACA) System implementation review to brief the Space Shuttle Program (SSP) Quality Manager on the status of ET implementation of NSTS 08126, Revision J. Based on a Program Requirements Control Board Directive approving implementation of NSTS 08126, the Marshall Space Flight Center Space Shuttle Projects received three

actions. The actions requested the submittal of an implementation plan for NSTS 08126, the submittal of an element problem trend analysis process and a review of all PRACA related Memorandum of Understandings (MOUs), Memorandum of Agreements (MOAs) and/or Avoid Verbal Orders (AVOs) to assure compliance with NSTS 08126. PAE provided a status which informed the SSP Quality Manager that direction has been given to the ET contractor to submit a proposal for scope and cost associated with implementation of NSTS 08126, Revision J and a trending process. In addition, a review yielded no PRACA related MOUs, MOAs or AVOs. The ET Project is currently awaiting the proposed implementation plan for evaluation and negotiation.

PAE participated in a meeting held with MSFC engineering personnel to discuss upcoming ET RTF bipod testing in the thermal vacuum chamber. The testing will be performed on 3' x 5' panels and will include 12 nominal thermal cycles and one cycle in which an intentional debond is introduced. The debond is being introduced due the fact that foam will debond during ascent. Personnel understood that Quality will verify that the debond has been introduced per the procedure; however, the issue arose as to how to document the debond operation. The meeting was held to reach an agreement on documenting the intentional debond operation. The team reached agreement that the debond steps will be added to the Test Stand 300 installation/removal procedure along with Quality verifications as to the performance of the intentional debond operation.

PAE participated in the ET Excitation Power Box (EPB) Critical Design Review (CDR) held 11/15/04-11/17/04 at MSFC. The EPB is designed to increase instrumentation measurements by providing excitation power from the ET to the Enhanced Data Acquisition System (EDAS) system. PAE submitted three Review Item Discrepancies (RID) and two comments. The RIDs were submitted against the End Item Specification, the Verification Plan and the Test Plan. There were approximately 40 RIDs submitted by the review teams and nine RIDs submitted against Safety and Mission Assurance documentation. There were no issues related to the design of the system. The Board was scheduled for 12/01/04.

PAE reviewed a test plan and participated in a telecon to discuss evaluation of scratches on epoxy primer beneath TPS. During the handling of the tank after primer has been applied, scratches and small pinholes in the primer taint the ET's surface, thus exposing the bare aluminum. The primer's sixteen hour cure time – required prior to the next processing step – causes time constraints in using the primer as a touch-up coating. The test plan explores the relationship between the size of a scratch versus the sacrificial nature of the primer to keep the scratch free of detrimental corrosion under the foam. PAE provided comments and recommendations to the test plan that included revising the categorization of the test and updating Quality Assurance involvement in the test fabrication and testing activities to assure test results could be used not only for Material Review Board disposition, but also for future updates to processing specifications. The test procedure section was also recommended for revision to take into account pad stay time.

PAE participated in the ET RTF Design Certification Review (DCR) Phase I at MAF the week of 12/06/04. PA engineers performed a bottoms-up review of the Hardware Certification Sheets (HCS) and Certificates of Qualification (COQ) to assure End Item compliance with Design Certification documentation. Ten HCS/COQs were available to evaluate for the RTF DCR I. PAE worked with Quality Engineering in generating 57 Review Item Discrepancies (RID) on inconsistencies between the HCS/COQ verification documentation and the Design Certification Sheets. The contractor worked a number of the initial RIDs prior to be Pre-Board; however, a number of discrepancies still existed. These discrepancies were documented on two final RIDs that were submitted to the Pre-Board.

## **4.7 Risk Management and Risk Assessment**

### **4.7.1 Risk Management**

During 1<sup>st</sup> Quarter of Fiscal Year 2005 Continuous Risk Management (CRM) continued to support QD10 and QD40 by providing an executive overview of CRM to the UNITES group. This group provides general computer services to all of MSFC and requested an overview of CRM to better understand operational risks across MSFC. The CRM process will assist in better management of resources. In addition to the CRM training an overview of the ePORT risk management database was given to the UNITES group. CRM PAE provided an executive overview of CRM to the In Space Propulsion (ISP) group. This group is part of the Exploration effort at MSFC and requested a refresher of the CRM process to better identify and understand all ISP related risks at MSFC. The review of the CRM process will assist the ISP team in better management of their resources and making clear and concise decisions for the success of the ISP. In addition to the CRM training an overview of the ePORT risk management database was given to the ISP group as tool for identifying, tracking and documenting all risk activity. CRM PAE reviewed the risk assessment template to be utilized in support of the CAITS task to identify and assess all MSFC projects/programs and their risk management process.

Risk Management (RM), Continuous Risk Management (CRM) and, Earned Value Management (EVM) were tasked to support a 4 hour CRM class by reviewing its material with QD40, and HEI's CRM team. RA/CRM/EVM also attended a 4 hour CRM training course as part of its PDRM training.

RM revised and updated the proposed SSP Risk Management Summary Card to include a more robust definition of Safety – Environmental Health, Mission Success-Operations and ISS Schedule Impact. Also included in this proposed update was the Timeframe element of the risk analysis.

RM attended the Shuttle Integrated Risk Management Application (SIRMA) training to support the SSP Risk Management effort. This training was provided by CRM support personnel from the Johnson Space Center. The benefits of having a certified SIRMA instructor at MSFC would reduce the amount of cost and travel time for JSC support personnel in order to travel to MSFC to provide the training.

CRM reviewed and assessed a risk management database called Risk Management Tool (RMT). This tool was designed and constructed by Hernandez Engineering Inc. (HEI) personnel to support NASA's Glenn Research Center effort for risk management support of the Jet Propulsion Laboratory (JPL) Exploration Office Safety and Mission Support contract. Preliminary findings indicate that this database is not adequate or robust enough to fill the risk management needs of the contract.

CRM actively supported weekly CRM Team Working Group to discuss/develop/prepare CRM Assessment Process. Products developed included CRM Assessment Letter for MSFC Center Director David King's signature, developing and preparing the Continuous Risk Management Assessment process checklist and matrix for determining CRM activity, and scoring level throughout MSFC.

CRM conducted CRM Executive Overview training for the ESMD Safety & Mission Assurance/QD10 office. A review of the CRM process/paradigm and how it will be applied to the ESMD effort was provided. After the class, the ESMD group reviewed their manning requirements to conduct CRM for the ESMD and requested the CRM group to assist on developing the ESMD executive level Risk Management Plan.

CRM Team members worked on a collaborative effort to develop the CRM process flow and documentation section for the ESMD Risk Management Plan.

RM conducted an overview of the Orbital Space Plane IRMA risk management database. This overview provided insight to the workings of the database and how it could be modified and integrated into the Shuttle Integrated Risk Management Application (SIRMA) to track Space Shuttle Program (SSP) integrated hazards. Currently, IRMA is on a MSFC web server and the programming code is available at no cost to HEI and NASA. It was agreed that HEI would forward the documentation and requirements for the SSP integrated hazard mechanism to the CRM group as soon as possible.

CRM supported/participated during the CRM Team Working Group. Topics included; CRM Final Website Discussion, Changes to Assessment Presentation and Continuous Risk Management Assessment process and documentation.

RM provided a rough draft of MSFC's Continuous Risk Management Maturity Assessment Plan and presented it to, SMO for coordination followed by a dry-run of the presentation which was presented to S&MA/QD40.

CRM personnel developed and reviewed the MSFC CRM Risk Assessment Process. This process is to be presented to the MSFC Center Director. The CRM Assessment Process will review four select projects/programs to evaluate their risk management process and determine the maturity of the CRM methodology.

#### **4.7.2 Space Shuttle Probabilistic Risk Analysis**

During 1<sup>st</sup> Quarter of Fiscal Year 2005 Probabilistic Risk Assessment (PRA) continued to support the Space Shuttle Program (SSP) by working with the SSME PRA team, on finishing up the review of SSME failure history, and working with the SSME Project lead to obtain feedbacks from other SSME system groups.

PRA supported a 4-day meeting with Shuttle PRA (SSPRA) Orbiter PRA team and SSPRA leads on data gathering and analysis, and formulate current PRA status, upcoming schedule, tasks, and deliverables.

PRA continued to make progress on screening and documentation of PRACA data for ET functional components failures for quantification step. SAPHIRE Fault Tree logic for ET has been reviewed and the data verified.

PRA completed its review of the Orbiter MPS, Hydraulic and Electrical PRA models in relationship to interfacing with the propulsion models and provided feedback/discussion on possible inconsistency in the above mentioned Orbiter models with the model integration lead. PRA has reviewed the draft outline of the SPRA (Shuttle PRA) data analysis documentation; finished updating SSME Throttling and MECO fault tree and data analysis; supported telecons with SSME PRA teams on modeling status; worked with the SRB PRA team logic model updates; discussed ET leak and functional data analysis with ET PRA team and supported the weekly SPRA status telecon with SPRA teams from JSC, HQ, MSFC and MSFC Prime Contractors.

PRA represented MSFC in an elicitation of RSRM catastrophic risks with a panel of RSRM experts at Thiokol's RSRM facility, 10/19/04. The elicitation was lead by NASA HQ. During SSP PRA's visit a tour was taken of Thiokol's RSRM facilities. SSP PRA also recently met with QD40 to define part time tasks in which to evaluate QRAS 1.8 (Beta testing).

PRA continued to; work with the SRB team in order to gather Likelihood data for Bayesian updating methodology; entering quantification information into SAPHIRE SRB Fault Trees; completing the development of the Fault Tree using CAFTA for Loss of Umbilical Signal Paths; and assisting S&MA in debugging Item QRAS Software.

PRA continued to work with the SSME PRA team and SSME Project on refining the SSME PRA data analysis results. Initial agreement was reached on preliminary SSME catastrophic and shutdown risks and associated failure discount rationales before presenting to the SSME Project Office. Several lengthy discussions were held with the SPRA model integration lead at JSC on SSME, ET and Orbiter MPS interface models to ensure consistency.

PRA produced and delivered an Excel spreadsheet analysis and summary of the results of the RSRM Elicitation conducted at Thiokol on 10/20/04.

PRA completed and delivered the baseline logic models to JSC to be integrated into the overall model. SSP PRA met with SRB Project office to discuss final results and also assisted S&MA in debugging Item QRAS Software.

PRA completed the SSME functional and interface data analysis and reviewed ET functional/ leak data analysis methodology and results. R&ME also completed the propulsion side model integration and attended a 2-day long model integration meeting with SPRA PRA lead and Orbiter PRA team. Minor modifications to propulsion elements and Orbiter MPS models were made as the result of the meeting. R&ME discussed Orbiter Data Processing System and Electrical interfaces with propulsion elements, with SPRA model integration lead, Orbiter DPS, and electrical PRA analysts.

PRA participated in the Shuttle PRA meeting at JSC (11-8 &9) for the purpose of reviewing SAPHIRE integrated scenario (cut set) risk rankings and to prepare and review presentations for the MSFC buy-in meeting. SSP PRA also participated in the Graphic Presentation meeting with Edward Tufte at JSC on 11-12. Management was critical of the ET seal leak analysis methodology for developing leak rate distributions. Consensus was reached on an alternate approach that uses orbiter MPS leak data as a surrogate for ET leak data. Work was started to quantify the risk using this approach. A Goodness-of-Fit statistical analysis was performed using Orbiter MPS leak data. Preliminary results for the probability of a leak exceeding the critical threshold rate are being developed and compared with the results from the previous quantification method. A meeting was held with HEI Special Projects engineer in order to strategize about using IRMA for support of the RTF Integrated Hazards effort. Part of this meeting was an excellent demonstration of IRMA's capabilities presented by the CRM team.

PRA JSC S&MA presented their preliminary Shuttle PRA results to the MSFC Project offices on 11/16/04-11/17/04. PRA also continued to perform beta-testing on QRAS Software in order to identify any programming bugs.

PRA worked with the Shuttle PRA (SPRA) model integration lead (JSC SMA) on resolving some last minute model integration issues. R&ME and JSC SMA presented these preliminary SPRA results to the SPRA team, and aided in the cursory review of the integrated models. R&ME presented the SSME PRA modeling methodology and results to MSFC SSME project and SMA offices. R&ME and JSC SPRA leads briefed the QD20 lead on Shuttle PRA status and upcoming schedule.

PRA began working on SRB PRA documentation for inclusion into its final reports. The SRB team has also completed modifying its PRA results and has sent them to JSC to be integrated into the overall fault tree.

PRA continued to write the propulsion elements' contribution to the Shuttle PRA (SPRA) Functional data analysis reports with inputs from the propulsion elements. R&ME performed additional sensitivity analysis on SSME catastrophic and benign shutdown analysis comparing the various way of constructing the Bayesian likelihood in support the functional data analysis in support of the functional data analysis.

PRA continued to conduct Beta testing of QRAS 1.8. The first phase of the evaluation is complete and results were presented to the R&M Team Lead at MSFC. The results of the analysis are being documented in a written report which will be delivered during the week of 12/20. A telecon is tentatively scheduled with ITEM next week to present findings of the evaluation and to gain insight into a number of issues pertaining to the next phase of the evaluation. In Phase II, a more thorough head-to-head evaluation of QRAS with SAPHIRE will be conducted using a complex fault tree from previous Shuttle PRA analyses. Phase II is a 60 day effort after which a recommendation will be made concerning the maturity of QRAS 1.8 and its fitness for use by S&MA for Exploration projects.

PRA supported the two-day TIM with SRB project, USA SRB engineering, and PRA representatives from JSC and HQ to review the top 12 SRB failure scenarios. R&M completed the first good draft of the propulsion element's section on SPRA functional data analysis report, and has submitted it to the SPRA team lead for integration into the final report.

PRA reviewed the preliminary draft of the Shuttle PRA Integration report from JSC PRA team lead.

#### **4.7.3 Shuttle Reliability Prediction and Risk Analysis**

During 1<sup>st</sup> Quarter of Fiscal Year 2005 Shuttle Reliability, Prediction & Risk Analysis (RA) continued to provide support by determining that of the last 12 Booster Separation Motors (BSMs) dissected, for the purpose of having their offsets measured, there appeared to be a trend in offset measurement as a function of the serial number. To date no serial numbers have been obtained as a function of time. However several BSM tiger team members were informed of this fact. RA is also looking into error limits on material properties of the graphite used in the BSMs. Error limits of measurements used in BSM discussions have often been neglected in the past. As a result RA raised several questions concerning the use of capacitance equations in BSM Non-Destructive Evaluation (NDE) work.

SSME ultrasonic fastener stretch measurement equipment was updated from relating Erdman counts to load to relating load to delta time. RA was asked to analyze the data for this testing. The main testing was performed at Canoga Park and MSFC is performing a portion of the testing here at MSFC in order to evaluate differences in location and to assure the accuracy of the readings at Canoga Park. RA continued to perform further data analysis of the fasteners of part 1 presenting its results to the team, working on the analysis of the sixth fastener of part 1 and beginning a summary of all fasteners in part 1.

Lockheed Martin (LMSS) engineers ran a Designed of Experiment (DOE) looking at factors affecting plug pulls and other properties of foam applied under different conditions for ET. RA was asked to independently assess the LMSS analysis on the data. A Statistical Support Team member and RA reviewed video and production data logger data to revise the dataset with actual Spray Temperature. This resulted in revised findings; adding a significant effect of Overlap Time on Plug Pull-Over Primer, but removing any significance of experimental inputs besides Number of Knit lines on Density. A final report has been submitted.

RA presented a talk to the Scottsboro High School this quarter on 'Jobs for Alabama Graduates'. The talk emphasized to the class the careers available in the field of mathematics.

RA verified and wrote summary papers on the BX-250 and BX-265 foam characterization analyses this quarter for the ET.

A team including RA was assembled at KSC this quarter in order to model the mass of foam lost in a divoting event. RA calculated the prediction limits of the as-built foam density using dissection data for this analysis.

RA presented an analysis of pitfalls in a database along with supplemental analysis using the limited data as the result of an independent team's use of an existing model that described mass loss during a divoting event on ET. Analyst received kudos from Independent Assessment team members for giving a clear, well-organized and persuasive presentation. RA was asked to follow the independent team's modeling process.

A team at KSC is modeling the mass of a foam projectile lost in a divoting event. RA was tasked to supply refined calculations of foam loss for automatic NCFI 24-124, manual spray BX-250 and BX-265 applications and foam density for PDL pour-foam applications. As a member of this team RA was tasked to help characterize and optimize the performance of three NDE techniques for identifying voids in foam and participate in a TIM and other meetings on experimental design. This included presenting to TIM participants and explanation of how DOE and logistic Probability of Detection (POD) experimental design and analysis techniques will be used to characterize and optimize the three methods. A proposal by the team to examine the newly sprayed 10-foot section of ET-120's Protuberance Aerodynamic Load (PAL) Ramp and to reexamine indications found using previous, less discriminatory NDE techniques on the existing PAL Ramp sprays was accepted by Lockheed and ET Project management. RA has written a straw man test matrices in order to: 1) make sure there is full agreement on the scope of each test plan; 2) make sure all test results will be analyzable, including being able to gauge effects of potential interactions; and, 3) be able to suggest improvements, such as combining tests and using fractional factorial designs (a Design of Experiments, or DOE, technique) to reduce the number of trials needed. RA is also negotiating particular layouts of test voids within specimens in order to improve analyzability. The new stringer closeout is the first case to be examined. RA is supplying input on experimental design and likelihood of test results to meet its objective through analysis.

Predictions continued to work on the Cracked Throat BSM project by finishing up on its error analysis on the bond line measurements provided by SRI. RA was also asked to assist with the review of the bolt stretch analysis involved in Test Report TR015214. RA recommended that the analysis be rejected as presented, since required bolt stretch data was not included in the variables; no tolerances were given on bolt stretch or any flange thickness measurements.

RA team members are now using the improved Logistic method to assess POD of flow liner cracks. Straw man test matrices were assembled and will be discussed at the next team meeting. It was found that some tests' test specimens, as produced, will afford only an attenuated view of the factors affecting POD, and could result in an overly conservative POD value. This would occur especially if there are interactions between experimental factors.

RA was tasked this quarter to give an overview of DOE along with some examples of designed experiments recently performed in support of the ET RTF effort to the R&M Team.

A team modeling debris transport required mass of foam lost in a divoting event, which in turn depends on foam density. RA's calculations of as-built foam density were defended to the larger team. The results were passed on for use in the debris transport assessment.

An NESC team from GRC built a model describing foam mass loss given a handful of input parameters. RA gave extensive input at the meeting. No method of model validation was addressed; RA suggested methods. Simpler models used for comparison were found to be too simple and thus not comparable, and no clear method of comparing model fits was presented; other models were suggested. No estimate of the

model error was presented with which to judge model adequacy. An issue of serious multi-collinearity of factors has not been explicitly addressed, though it was not clear that the model does not adjust for this automatically. In broader scope, the problem of correctly designed experimental matrices was discussed. One or a series of designed experiments could have resulted in less ambiguous results, making this issue moot.

RA was asked to assist in setup of a test to determine variability in transducer reseats for ultrasonic pulse readings. RA prepared a designed experiment to obtain maximum information about the process. RA also proposed a stability study to ascertain machine variation over time.

Predictions reviewed several measurements on BSM cracked throat project this quarter. Most of the results that were quoted did not have any tolerances. RA continues to stress the importance of providing tolerance information whenever measurements are presented.

Predictions conducted a review of analysis techniques in the literature concerning O-Ring resiliency tests for this quarter.

RA helped with enhancing a summary presentation of the analyses previously performed comparing properties BX-250 v BX-265, automatic v manual spray in tests, properties of new v old tin catalyst in tests, BX-250 v BX-265 divot sizes in tests, and BX-250 v BX-265 density in as-built spray. The results are to be presented at a Pre-Board meeting in early January 2005.

RA reviewed the ET Leak Analysis paper written by HEI's Special Projects Engineer this quarter. Edits were incorporated into the document with a second draft to be ready for review in the first week of 01/05.

Predictions worked on the review of free response testing of O-Rings used in RSRMs. The current problem with the previous tests is the lack of adequate repeatability. The free response tester shows a much better repeatability and is recommended as a replacement for the other tester currently in use by ATK Thiokol.

#### **4.7.4 Advance Projects Risk Assessment**

During 1<sup>st</sup> Quarter of Fiscal Year 2005 RA continued to provide support by collaborating with QD40 to investigate apparent inconsistencies encountered in plotting uncertainty bounds to compare multiple risk estimates that differ by a factor of more than 10. The original plots on a risk scale showed what appeared to be greatly different uncertainty bounds for estimates that have the same error factor. The error factor is defined as the ratio of the 95 percent confidence limit on risk divided by the 50 percent confidence limit. RA and QD40 determined that by plotting MTBF (1/risk) on a Logarithmic scale, the apparent inconsistency can be eliminated. Some care must be taken in comparing error factors for estimates of very high risks to those for very low risks, but the error factor is an effective tool in communicating the degree of uncertainty in a risk estimate.

RA represented MSFC this quarter as a reliability expert by actively supporting the ETT Final briefing at NASA HQ. RA answered questions regarding Loss of Crew (LOC) and Loss of Vehicle (LOV) analysis, and explained some basic concepts of reliability, including Boolean logic and uncertainty analysis, to a receptive audience. RA continued to support this effort by satisfactorily addressing concerns from the MSFC director by answering more in-depth questions regarding analysis performed in these studies.

RA was also tasked to support the CEV requirements team this quarter by completing a matrix regarding the validation of the CEV Spiral 1 Level 2 requirements.

RA participated in the SAE G11 Conference in Huntsville, AL. RA set up a booth displaying S&MA and HEI products and capabilities. RA created a video and brochures for the Statistical Tool for Assessing the Risk of Space-exploration (STARS), and displayed them for the conference attendees.

RA participated in the PRAXI-5 Conference in Cleveland, OH this quarter. RA was invited by NASA to lecture on its presentation entitled "Application of PRA During Conceptual Design for the NASA OSP". The presentation sparked many questions, and was well received by those in attendance.

RA produced an estimate on the amount of resources in Full Time Equivalents (FTE) it would take NASA to successfully maintain a Reliability, Maintainability, and Supportability (RMS) Program and a PRA Program for the entire scope of the ESMD. The FTE estimate was a NASA-wide estimate consisting of only the FTE needed for Civil Servants and Support Contractors.

RA, under QD10, worked with QD40 to produce Level 2 Reliability, Maintainability, and Supportability (RMS) and PRA requirements tracing them to the Exploration Crew Transportation System level 1 requirements for Spiral 1 revision A. The Level 2 Requirements produced consisted of an allocation of the level 1 ascent probability requirement to the Crew Exploration Vehicle (CEV) and the CEV Launch Vehicle (CEVLV), and requirements based on a Failure Modes and Effects Analysis (FMEA) and a Problem Reporting and Corrective Action System (PRACA). Additionally, these requirements were traced to NPR 8705.2 Human Rating Requirements Document Requirements.

RA was tasked this quarter to produce a contractor Statement of Work (SOW) for implementing an Integrated Reliability, Maintainability, and Supportability Program and a Probabilistic Risk Assessment Program for the Constellation Program.

## **5.0 COST REDUCTION ITEMS**

Our continuing cross-utilization of employees, continuous analysis of work in progress to assure that application of resources meets the needs of the task, and the judicious acquisition and distribution of tools to enhance the efficiency of all team members allow us to minimize cost to the customer.